TELEDYNE INSTRUMENTS
Test Services
A Teledyne Technologies Company

TECHNICAL ENGINEERING PROCEDURE

TEP-3-013

REVISION 11

TITLE:

INSTALLATION PROCEDURE FOR TELEDYNE QUICK STEM SENSOR ON VALVE STEM FOR MEASUREMENT OF THRUST AND TORQUE

PROPRIETARY

ORIGINATOR: David E Thrall **DATE:** 4-6-07

APPROVED FOR RELEASE: [signature] **DATE:** 4-6-07

GENERAL MANAGER

REVIEWED: [signature] **DATE:** 04/06/07

QUALITY ASSURANCE

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1.0 SCOPE

1.1 This procedure provides instructions for the installation of Teledyne Instruments – *Test Services* (TTS) Quick Stem Sensors (QSS) on the stems of Motor Operated and/or Air Operated Valves (MOV/AOV).

The QSS is a strain gage transducer that measures the Torque and Thrust parameters of the MOV or AOV. TTS classifies QSS installations as permanent or temporary and low temperature or high temperature.

This procedure applies to all TTS Quick Stem Sensors (QSS) on the stems of rising stem and rotating-rising stem valves and the shafts of butterfly valves.

2.0 APPLICATION

2.1 The QSS installation classifications differ in their adhesive requirement and how the appropriate adhesive is mixed and cured. All of the following pre-requisites are required, used or performed for all of the installation classifications:

1. equipment
2. materials
3. method

2.2 A normal temperature, permanent QSS Installation consists of a QSS, Part Numbers TES-xxxxTT350, TES-xxxxTQ350, or TES-xxxxTH350, installed with EPY-500 Adhesive. The QSS foil backing material and the solder connections of the lead wire to the QSS establish the 0 to 350 degree Fahrenheit normal operating temperature range of the QSS. The EPY-500 is packaged in a separated envelope, as a two-component pre-measured adhesive. The EPY-500 Adhesive is heat cured per the cure requirements in Section 8.0.

2.3 A high temperature, permanent QSS Installation consists of a QSS, Part Numbers TES-xxxxTT350HT, TES-xxxxTQ350HT, or TES-xxxxTH350HT,

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installed with EPY-500 Adhesive. The HT QSS uses different foil material and solder and has a 0 to 500 degree Fahrenheit temperature range. The EPY-500 Adhesive is post-cured for this installation; see its curing and post cure requirements in Section 8.0.

2.4 A low temperature, permanent QSS Installation consists of a QSS installed with EPOWELD – 3672 Adhesive. The adhesive is the factor that limits the upper operating temperature. EPOWELD – 3672 Adhesive has a temperature range of 0 to 180 degrees Fahrenheit. This adhesive does not require a heat cure; see its curing schedule in Section 8.0.

2.5 A low temperature, permanent QSS installation can also consist of a QSS installed with X60 Adhesive. X60 has a test temperature range of –328 to +176 degrees Fahrenheit. This adhesive does not require a heat cure; see its curing schedule in Section 8.0.

2.6 A low temperature, temporary QSS Installation consists of a QSS installed with M – Bond 200 Adhesive. The adhesive limits this installation to a temperature range of 0 to 150 degrees Fahrenheit and to short-term cycling. The adhesive bonding properties may fail over long-term use. See Section 8.0.

2.7 When the QSS thrust and torque sensitivities are being determined from a calculation instead of a calibration, Design Engineering or equivalent shall provide the values of E and μ. The basis document shall be referenced on the calculation sheet.

2.8 The Sensitivity Calculation Worksheets in Section 9.0 is used to calculate the torque sensitivity and/or the thrust sensitivity of the QSS Installation. The diameter of the stem and the stem material properties - Young's Modulus and Poisson's Ratio -- are required when performing the Sensitivity Calculation. The stem material properties (Young's Modulus and Poisson's Ratio) in Section 10.0 can be used when the stem material properties

information is not available and/or the plant Engineering Department accepts the TTS Stem Material Properties Recommendations.

This stem material listing is referenced from Teledyne Brown Engineering – Engineering Services Calculation Package Document, CP-A-722-2.

To calibrate a QSS Installation, see Teledyne Engineering Procedure TEP-3-023, titled "In-Situ Calibration of Plant Valve Stems Instrument with Thrust and Torque-Sensing Strain Gage Bridges Using QUIKCAL".

3.0 PREREQUISITES

3.1 The following prerequisites must be satisfied prior to the start of QSS installation:

a) The valve(s) to be instrumented should be taken out of service by the utility following its established procedures. If the valves cannot be taken out of service, coordination with the control room shall be obtained.

b) Drawings of the valve(s) must be available to determine the stem or shaft material.

c) The location on the stem where the QSS is to be mounted must have a smooth surface.

d) The personnel must be certified to the level required for the task to be performed.

e) Access to the valve(s) must be provided (including staging, if required).

f) Electric power must be available at the valve.

g) The Radiological Condition Report for the valve and its surroundings must be available.

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h) Radiological protection commensurate with the existing site conditions must be used.

3.2 The following personnel responsibilities apply:

a) Project Manager

I) Ensure that valve walk-down data requested by the MOV QSS Installation Log (Section 9.0) is available to the field QSS installation personnel .

II) Designate an On-site Installation Supervisor

III) Provide justification for all QSS Installations that are close to a transition (Section 6.1.4 a).

b) On-Site Installation Supervisor

I) Verify that valve sensor installation and documentation are correct and complete (Section 9.0).

II) Accept valve sensor installation.

c) Technician

I) Perform surface preparation and QSS Installation in accordance with the requirements of this procedure.

II) Obtain approval from Project Manager for QSS Installations that are closer to stem transitions than the required two times the depth of the transition (Section 6.1.4 b).

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d) Client

I) Provide safe and adequate access to all locations designated by the TTS On-Site Supervisor.

II) Complete client portion of installation log for each valve, prior to installation team deployment.

4.0 EQUIPMENT

A) Measuring Scale
B) Ball Point Pens, Pencils
C) Lights
D) Inspection Mirror (if necessary)
E) Digital Multimeter capable of measuring > 100 Megohms Resistance
F) Calibrated Micrometer
G) P-3500 Vishay Strain Indicator or equivalent
H) QSS Holder (Optional)

5.0 MATERIAL

A) 80 or 100 Grit Silicon Carbide Paper
B) 220 or 240 Grit Silicon Carbide Paper
C) M-Prep Metal Conditioner
D) Gauze Pads, Tissues, or Lint Free Wiping Materials
E) Cotton Swabs
F) M-Prep Neutralizer
G) M-Bond 200, (for temporary QSS Installations)
H) EPY-500, (for permanent and high temperature QSS Installations)
H) *Epoweld 3672 (low temperature QSS Installation)
I) X60
J) RTV 3145
K) M-Coat C
L) Acetone, Methyl Ethyl Keytone, or Approved Solvent

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M) Clamping Device

N) Heaters

*Available in Hardman unique green and white job size packages (U.S. Patent Double/Bubble 326625)

6.0 METHOD

6.1 Determine Location of QSS Installation

6.1.1 Interference of the QSS Installation with the packing, packing retainer, or actuator must be avoided. Approximately 1/8 inch radial clearance is required if the installation must enter an enclosed space such as the packing retainer.

6.1.2 Mark the stem at the point where it enters the packing and where it enters the actuator. Stroke the valve to the opposite position, i.e., closed if originally open; or open if originally closed, and again mark the stem where it enters the packing and actuator. The length of the stem between the inner pair of the four marks on the stem will be the area available for the installation of the QSS.

Note: If the valve is unavailable for stroking, the length of stem travel may be provided by client. From the length of stem travel, determine the section that will be clear of the actuator and packaging. This will be the location of the QSS Installation.

6.1.3 Using a calibrated micrometer, measure the stem diameter and record it on the QSS Installation Log (Section 9.0).

6.1.4 The following guidelines are to be followed when installing a QSS on or near a stem transition. Typical stem transitions include anti-rotation devices, keyways, threads, shoulders and undercuts.

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a) Uncalibrated

When calculating thrust and torque output sensitivities, the QSS must be installed on a smooth section of the stem and located at a distance of at least two times the depth of the transition away from the transition. The QSS may be placed on or closer to the transition with approval of the TTS Project Manager when justification can be provided, based on either finite element analysis and/or a laboratory verification test, that the discontinuities do not affect the calculated sensitivities.

b) Calibrated

When the thrust and torque sensitivities are to be determined by in-situ calibration, the QSS may be placed closer to the stem transition than stated above or on stem transition areas with no effect on the calibrated sensitivities. For such installations, the installation logs (Section 9.0) must be reviewed and approved by the Project Manager.

6.2 Surface Preparation for QSS Installation

Note: Surface temperature shall be 77°F ±7°F when using Epoweld 3672.

6.2.1 Degrease the surface to which the strain gage is to be bonded with acetone, methyl ethyl keytone (MEK), or an approved degreasing solvent.

6.2.2 Abrade the specimen surface with 80 or 100 grit silicon carbide paper, removing all rust, corrosion, or oxidation.

6.2.3 Degrease the surface removing all residue left from the abrading process.

6.2.4 Cut several strips of 220 or 240 grit silicon carbide paper. Wet the paper with M-Prep metal conditioner and abrade the surface.

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6.2.5 Remove the M-Prep Conditioner and abrasive residue with a tissue or gauze pad over the specimen area. This step may have to be repeated to ensure that the conditioner has been removed.

6.2.6 Clean and scrub the specimen with M-Prep Neutralizer. This step should be repeated until there is no evidence of contamination on the specimen surface. The scrubbing is normally performed with cotton swabs, gauze, or a clean wiping material (e.g.: cloth, tissue, etc.).

6.2.7 If possible, do not allow the conditioner or neutralizer to dry on the surface by evaporation. Wipe the surface with a dry tissue or gauze pad before proceeding to the next step.

6.2.8 Technician shall sign installation log when surface preparation is complete (Section 9.0).

6.3 Prepare the QSS for Installation

6.3.1 Abrade the inside or rear surface of the QSS lightly using 220 or 240 grit silicon carbide paper. Clean using degreaser and tissue.

6.3.2 Clean surface with M-Prep Metal Conditioner. Apply sparingly, spread and scrub lightly until beads disappear. Do not let excess conditioner migrate to other side of QSS. Dry with tissue.

6.3.3 Apply M-Prep Neutralizer to the back of the QSS. Dry using tissue or gauze pad.

6.4 QSS Installation

6.4.1 Select the adhesive to be used on the basis of the QSS Installation Classification, see Section 2.0, steps 2.2 through 2.6.

6.4.2 Prepare the adhesive for use following the manufacturer's instructions summarized in Section 8.0 of this procedure.

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NOTE: Epoweld 3672 Adhesive (Skip to Step 6.5).

M – Bond 200 Adhesive (Skip to Step 6.6).

X60 Adhesive (Skip to Step 6.7).

6.4.3 Apply the EPY-500 Epoxy in a continuous band completely around the stem at the desired location; the band should be slightly wider than the QSS. Also apply the epoxy to the prepared inside surface of the QSS in a thin, even coating.

6.4.4 Carefully apply QSS to stem; open sensor only enough to clear stem diameter. While holding the QSS in its intended location with thumb and forefinger, apply the spring clamp to the QSS clip blocks with the other hand (Section 7.0, Figure 1).

6.4.5 Remove excess adhesive.

6.4.6 To cure the EPY-500 Epoxy, install heaters and a thermocouple as close as possible to the QSS. Secure the thermocouple so that it is held in intimate contact with the stem, preferably between the heater and the QSS. Follow the cure schedule summarized in Section 8.0.

6.4.7 Monitor the stem temperature with a thermocouple until the cure temperature is reached and let the installation remain at that temperature until fully cured. If the installation is a high temperature application follow the cure schedule and do a post cure.

6.4.8 After curing unplug the heater and let the valve stem cool to approximately 100°F to permit heater removal.

6.4.9 Remove heater, thermocouple, and clamps. Inspect the QSS Installation and, if it is acceptable, abrade the excess cement away from the perimeter and clean with solvent.

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6.5 EPOWELD 3672 Adhesive

6.5.1 Apply the epoxy in a continuous band completely around the stem at the desired location; the band should be slightly wider than the QSS. Also apply the epoxy to the prepared inside surface of the QSS in a thin, even coating.

6.5.2 Carefully apply QSS to stem; open sensor only enough to clear stem diameter. While holding the QSS in its intended location with thumb and forefinger, apply the spring clamp to the QSS clip blocks with the other hand (Section 7.0, Figure 1).

6.5.3 Remove excess adhesive.

6.5.4 No heater or temperature indication is needed as long as the stem temperature remains at room temperature, 77 degrees, ±7 degrees Fahrenheit.

6.5.5 Follow cure schedule as outlined in Section 8.0.

6.5.6 After cure inspect the QSS Installation and, if it is acceptable, abrade the excess cement away from the perimeter and sparingly clean with solvent.

6.6 M–Bond 200 Adhesive

6.6.1 The technician installing the QSS should be familiar with the characteristics of M-Bond 200. Initial curing occurs in seconds and a full cure occurs in one minute at 70°F.

6.6.2 Sparingly apply the catalyst (blue bottle) in a continuous band completely around the stem at the prepared location; the band should be wider than the QSS. Allow the catalyst to dry approximately one minute.

6.6.3 Apply the adhesive to the prepared inside surface of the QSS in a generous, even coating.

6.6.4 Carefully apply QSS to stem; open sensor only enough to clear stem diameter. While holding the QSS in its intended location with thumb and forefinger, apply the spring clamp to the QSS clip blocks with the other hand (see Section 7, Figure 1).

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Note: This step must be performed quickly and precisely due to the rapid curing time of M-Bond 200 (see handling precautions in Section 8.0).

6.6.5 Remove excess adhesive.

6.6.6 Maintain spring clamp pressure for five minutes. Inspect the QSS Installation and, if it is acceptable, abrade the excess cement away from the perimeter and sparingly clean with solvent.

6.7 X60 Adhesive

6.7.1 Apply the epoxy to the prepared inside surface of the QSS in a thin, even coating.

6.7.2 Carefully apply the QSS to the stem; open the sensor only enough to clear the stem diameter. While holding the QSS in its intended location with thumb and forefinger, apply the spring clamp to the QSS clip blocks with the other hand (see Section 7, Figure 1).

6.7.3 Remove excess adhesive.

6.7.4 No heater or temperature indication is required. Curing is complete after 15 – 20 minutes.

6.8 QSS Post-Installation Checks

6.8.1 Using a multimeter capable of making >100 megohm resistance measurements such as the Fluke 8020A measure the input and output resistances and the bridge-to-ground leakage. Record these readings on the installation log (Section 9.0).

a) The measured input and output resistances are the QSS input and output resistance with a tolerance of ±5 ohms. This measurement is made at the QSS with a short adapter cable to the multimeter.

b) The measured bridge-to-ground leakage resistance should be greater than 100 megohms.

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c) The installation log should be filled in completely, including the installer, date, QSS part and serial numbers, products used, expiration dates and lot numbers. The as-built section of the installation log shall show the final configuration of the valve stem with the QSS installed. Record all relevant dimensions.

6.8.2 Connect the QSS to a P-3500 Vishay Strain Indicator or equivalent and record the balance of the Wheatstone bridges on the QSS Installation Log.

6.8.3 Probe all of the QSS strain gages with your finger. The strain indicator will change slightly, but when the pressure from your finger is released, the indicator should return to its initial reading within 10με indicating there is an adequate bond between the QSS and the valve stem. If a shift greater than 10με remains after the probe test, then the QSS should be replaced.

6.8.4 The On-Site Supervisor or his designee shall review the installation and test results and signify his acceptance by signing off on the QSS Installation Log at the "Inspected By" section.

6.9 Moisture Proofing the QSS Installations

6.9.1 Degrease the area around the QSS Installations.

6.9.2 Apply M-Coat C over the QSS and over a 360-degree band around the valve stem QSS location.

6.9.3 After the M-Coat C has dried, apply RTV 3145 over the installation.

6.9.4 Repeat the thrust and/or torque bridge tests after waterproofing and record results on the log sheet (Section 9.0).

6.10 QSS Sensitivity

6.10.1 The QSS sensitivity must be determined either by calibration or by calculation.

a) The sensitivity calculation on Page 25 can be performed for QSS installations on solid stems, subject to the location limitations in Section 6.1.4 a. The

sensitivity derived from this calculation will provide an inaccuracy statement for the QSS installation of +/-8.1 per cent.

b) The sensitivity calculation on Page 26 must be performed when a SMARTSTEM has been repaired by replacing the original strain gages with a QSS or singular bonded strain gages. The sensitivity derived from this calculation will provide an inaccuracy statement for the repaired installation of +/-5%. Reference: TTS Technical Report TR-A100-18.

b) Laboratory testing of a model is required when the QSS is located close to or in a stem transition area as stated in Section 6.1.4 a). The model is made from the same material and machined to the same geometry of the valve stem. A test report is provided that documents what the inaccuracy statement is for this QSS installation only.

c) Calibration may be performed to achieve a higher accuracy for the QSS installed on a smooth section of the stem or to derive the sensitivity for a QSS located in a transition zone. Typical inaccuracy statements for calibrated installation are 3 to 5%. See TTS Procedure TEP-3-023, titled "In-Situ Calibration of Plant Valve Stems Instrument with Thrust and Torque Sensing Strain Gage Bridges".

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7.0 FIGURE 1 - QSS INSTALLATION TECHNIQUE

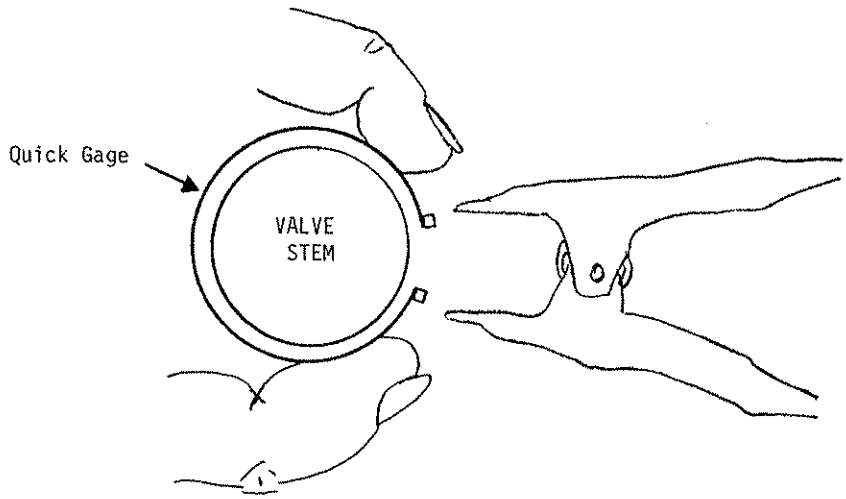

FIGURE 1

SECTION	DESCRIPTION	REV.

8.0 **Epoxy Mixing Instructions and Cure Schedule**

SECTION	DESCRIPTION	REV.

BLH EPY-500 Mixing Instructions

1. Knead the resin and powder prior to releasing the clamp that separates the hardener from the resin.

2. Release the clamp and knead the bag until the parts are thoroughly mixed and a uniform color results. Special attention should be given to the corners of the bag.

3. Snip off one corner of the bag. The adhesive may be squeezed out as desired.

4. The viscosity of the adhesive may be lowered to facilitate mixing or application by heating. Immersion of the package in warm water (120-140F/49-60C) prior to mixing or exposure to a heat lamp at the same temperature after mixing and removal from the package will yield the desired viscosity. Be sure to wipe the package free of moisture before opening if immersed.

5. The pot life (after mixing at normal ambient conditions) is approximately 24 hours. Pot life may be extended to one month if kept frozen when not in use. Moisture may condense on the package after removal from cold storage. This moisture must be removed before the package is opened to avoid contamination.

BLH EPY-500 Cure Schedule

Use any of the following:

1. 26 hours at 200°F

2. 4 Hours at 250°F

3. 1 Hour at 350°F

4. Post Cure – 1 Hour at 450°F for applications above 450°F or 1 Hour at 50°F above the stem's normal operating temperature.

SECTION	DESCRIPTION	REV.

EPOWELD 3672 Mixing Instructions and Cure Schedule

1. The individual components containing fillers should be stirred or agitated without introducing excessive air before use to ensure that all fillers are properly dispersed. To obtain best cured properties, accurate proportioning and thorough mixing are essential.

2. Mix Ratio:

	Parts By Weight	Parts By Volume
Part A	100	8
Part B	60	5

3. Cure Schedule: 12 Hours at 77°F.

4. ** Use of the Hardman two component pre-measured packages is encouraged.

M-Bond 200 Shelf Life and Handling Precautions

1. Unopened M-Bond 200 Adhesive has a shelf life of nine months when stored under normal laboratory conditions. Life can be extended if upon receipt the unopened material is refrigerated (+40°F). Due to possible condensation problems, which will degrade adhesive performance, care should be taken to ensure that the M-Bond 200 has returned to room temperature equilibrium before opening. Refrigeration after opening is not recommended.

2. M-Bond 200 is a modified alkyl cyanoacrylate compound. Immediate bonding of eye, skin, or mouth may result upon contact. Causes irritation. The user is cautioned to:

   a) avoid contact with skin

   b) avoid prolonged or repeated breathing of vapors

c) use with adequate ventilation.

For additional health and safety information, consult the material safety data sheet, which is available upon request.

X60 Mixing Instructions and Cure Schedule

1. Cut off the bottom of the outside plastic envelope (at the end with the green plastic divider) and remove the package of adhesive
2. Grasp both ends of the adhesive package and pull apart firmly to remove the plastic divider.
3. Pull the adhesive package back and forth over any exposed right angled corner (e.g., table top, box) until the parts are thoroughly mixed. This takes only about 10 – 15 seconds.
4. Snip off one corner of the bag. The adhesive may be squeezed out as desired.
5. The pot life (after mixing at normal ambient conditions) is approximately 2 to 5 minutes. The cure time is 15 to 20 minutes at ambient temperature.

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QUICK STEM SENSOR INSTALLATION LOG

Client: _____ Station: _____

Valve Tag No.: _____ Date: _____

Valve Type: Rotating Rising Stem _____ Rising Stem _____

Butterfly _____

System Temperature: _____ °F

Teledyne QSS Part No.: _____ Serial No.: _____

Thrust Bridge Input Resistance: _____ Ω

Thrust Bridge Output Resistance: _____ Ω

Thrust Bridge Gage Factor: _____

Torque Bridge Input Resistance: _____ Ω

Torque Bridge Output Resistance: _____ Ω

Torque Bridge Gage Factor: _____

Adhesive: _____ Expiration Date: _____

Lot # _____

Stem Diameter at QSS Location: _____

Encapsulation: _____ Expiration Date: _____

Lot # _____

Encapsulation: _____ Expiration Date: _____

Lot # _____

(1) Attach copy of Strain Gage Certification Sheet.

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QUICK STEM SENSOR INSTALLATION LOG

Valve Tag No.: _____

QSS TESTS:

Bridge Tests	Thrust		Torque	
	Before Waterproof	After Waterproof	Before Waterproof	After Waterproof
Bridge Balance				
Input Bridge Resistance (White-Green)				
Output Bridge Resistance (Black-Red)				
Leakage, Bridge to Ground >100 Megohms	Sat/Unsat	Sat/Unsat	Sat/Unsat	Sat/Unsat
Probe Test	Sat/Unsat	N/A	Sat/Unsat	N/A

Surface Prep By _____ Date _____

QSS Installation By _____ Date _____

QSS Tests By _____ Date _____

Inspected By _____ Date _____

Note: **If information in the following section is included in plant QSS Installation Records, do not duplicate.**

Instrument Calibration Dates

Multimeter:

Mfr _____ Model _____ S/N _____ Next Cal _____

Strain Indicator:
Mfr _____ Model _____ S/N _____ Next Cal N/A

Micrometer:

Mfr _____ Model _____ S/N _____ Next Cal _____

SECTION | DESCRIPTION | REV.

QUICK STEM SENSOR INSTALLATION LOG

QSS AS-BUILT SKETCH

Valve Tag: _____

QSS Serial Number: _____

Completed By: _____ Date: _____

Project Manager Approval (as required): _____ Date: _____

Top of Valve Stem

Sketch in the installed location of the QSS and provide the following dimensions:

_____ 1. Stem diameter @ QSS location

_____ 2. Depth of nearest stem transition

_____ 3. 2.0 x #2 (above)

_____ 4. Edge of QSS to nearest stem transition.

QSS located INSIDE/OUTSIDE transition zone:

If #3 above > #4 above, circle "INSIDE" otherwise, circle "OUTSIDE"

For all QSS installations INSIDE transition zones, obtain approval from the Project Manager.

SECTION DESCRIPTION REV.

QUICK STEM SENSOR INSTALLATION LOG

Sensitivity Calculations (Optional)

When using TTS stem strain gages with MOV diagnostic systems other than Teledyne's, calculate torque and thrust sensitivity in accordance with the following equations:

$$\text{Torque Sensitivity} = 16.363 \frac{D^3E}{(G.F.)(1+\mu)} \quad \frac{lb-ft}{mV/Vexc}$$

$$\text{Thrust Sensitivity} = 1570.8 \frac{D^2E}{(G.F.)(1+\mu)} \quad \frac{lbf}{mV/Vexc}$$

Stem Material =_____ _____
Reference Document

D = Stem Diameter =_____inches

E = Young's Modulus of Stem Material/10^6 =_____lb_f/in^2 _____
Reference Document

μ = Poisson's Ratio of Stem Material =_____ _____
Reference Document

G.F. =Gage Factor of Strain Gage

Thrust G.F. _____ Torque G.F._____

Vexc = Excitation Voltage = (volts d.c.)

Note: Vexc, the strain gage excitation voltage, should be verified and recorded as part of the test procedure.

$$\text{Torque Sensitivity} = 16.363 \frac{(\quad)^3(\quad)}{(\quad)(1+\quad)} = \frac{\text{lbf-ft}}{\text{mV/Vexc}}$$

$$\text{Thrust Sensitivity} = 1570.8 \frac{(\quad)^2(\quad)}{(\quad)(1+\quad)} = \frac{\text{lbf}}{\text{mV/Vexc}}$$

Valve Tag: _____

Calculation Performed By _____ Date _____

Calculation Verified By _____ Date _____

SECTION **DESCRIPTION** **REV.**

SMARTSTEM REPAIR SENSITIVITY CALCULATION

Utility: _____ Site: _____ Project No. _____

TELEDYNE SMARTSTEM: Serial No._____ Model No._____

Replaced original strain gages with: ☐ Individual gages ☐ QSS

Part No._____ Serial No. _____

Thrust Gage Factor _____ Torque Gage Factor_____

Performed by: _____ Date: _____

THRUST: Capacity _____ lbs.

Original data: Gage factor _____ Sensitivity _____ lbs/mV/V

New data: Gage factor _____

New sensitivity = original sensitivity x $\frac{\text{old gage factor}}{\text{new gage factor}}$

= _____ x _____ = [ ] lbs/mV/V

TORQUE: Capacity _____ ft-lbs

Original data: Gage factor _____ Sensitivity _____ ft-lbs/mV/V

New data: Gage factor _____

New sensitivity = original sensitivity x $\frac{\text{old gage factor}}{\text{new gage factor}}$

= _____ x _____ = [ ] ft-lbs/mV/V

Performed by:_____ Date:_____

Verified by: _____ Date:_____

SECTION	DESCRIPTION	REV.

10.0 Material Properties Listing

TELEDYNE BROWN ENGINEERING - Engineering Services

BY _____ DATE 8-26-97
CHKD. BY _____ DATE 8/27/97

Properties for Specific
Valve Stem Materials
CP-A-722-2, Rev. 0

SHEET NO. 6 OF _____
PROJECT NO. A722

3.0 Results

The following table summarizes the overall combined mean values of $E/(1+\mu)$ as determined by the SMARTSTEM database query. The value of E (modulus of elasticity) for each material is selected to correspond with the E at 70°F from the Aerospace Structural Metal Handbook. Then the value of μ (Poisson's ratio) is derived from the expression, i.e., $\mu = [(E \text{ at } 70°F)/(E/(1+\mu) \text{ result}) - 1]$.

Specification	E (10⁶)	μ	E/(1+μ)	Variance	Reference
(Tested) Alloy 17-4 PH	29.1	0.271	22.90		App. A
(ASMH, Alloy 17-4 PH)	29.1	0.291	22.54	-1.572%	App. I, 1501
(Tested) Type 410	31.6	0.277	24.75		App. B
(ASMH, Type 410)	31.6	0.27	24.88	+0.525%	App. I, 1401
(Tested) Type 416	31.6	0.286	24.57		App. C
(ASMH, 416; 410 mod)	31.6	0.27	24.88	+1.262%	App. I, 1401
(Tested) Type XM19	28.0	0.291	21.69		App. D
(ASMH, Type XM19)	N/A	N/A	N/A	N/A	App. I index
(Tested) Alloy A-286	29.0	0.281	22.63		App. E
(ASMH, Alloy A-286)	29.0	0.292	22.44	-0.840%	App. I, 1601
(Tested) Type 316	28.2	0.285	21.95		App. F
(ASMH, Type 316)	28.2	0.294	21.79	-0.729%	App. I, 1307
(Tested) Alloy L-605	33.5	0.279	26.19		App. G
(ASMH, Alloy L-605)	33.5	0.286	26.05	-0.535%	App. I, 4302
(Tested) Alloy 718	29.0	0.258	23.06		App. H
(ASMH, Alloy 718)	29.0	0.294	22.41	-2.819%	App. I, 4103

N/A: specific data not available

A review of the variances of the values of $E/(1+\mu)$ from the published data from those of the test data indicates that the property data from the ASMH is within the allowable variance of ± 3.50%. Therefore, the material property values for appropriate stem materials from the ASMH could be used to calculate the thrust and/or torque sensitivities for uncalibrated QSS's without invalidating the ± 8.2% accuracy claim.

SECTION	DESCRIPTION	REV.

TELEDYNE BROWN ENGINEERING - Engineering Services

BY _____ DATE 8-26-97
CHKD. BY _____ DATE 8/27/97

Properties for Specific Valve Stem Materials CP-A-722-2, Rev. 0

SHEET NO. 7 OF _____
PROJECT NO. A722

4.0 Recommendations

TBE recommends using the following values of $E/(1+\mu)$ for these materials when calculating the thrust and/or torque sensitivities for Quick Stem Sensors™ to maintain the uncalibrated accuracy of ± 8.2%. Use of other values of $E/(1+\mu)$ are allowed if within the ± 3.50% of the recommended values.

Common Alloy Name	Alternate ASTM / Other Designations	Alternate ASME Designations	$E/(1+\mu)$
Alloy 17-4 PH	A461 Type 630		22.90
(annealed and	A564 Type 630	SA564 Type 630	
all heat treat's)	A705 Type 630	SA705 Type 630	
Type 410	A182 Gr. F6	SA182 Gr. F6	24.75
(annealed and	A182 Gr. F6a	SA182 Gr. F6a	
all heat treat's)	A182 Gr. F6a CL1, 2, 3, 4	SA182 Gr. F6a Class 1 & 2	
	A182 Type 410		
	A276 Type 410		
	A314 Type 410		
	A473 Type 410		
	A479 Type 410	SA479 Type 410	
Type 416	A314 Type 416		24.57
(annealed and	A473 Type 416		
all heat treat's)	A582 Type 416		
Type XM19	A182 Type FXM19	SA182 Type FXM19	21.69
	A479 Type XM19	SA479 Type XM19	
Alloy A-286	A638 Type 660	SA638 Type 660	22.63
	A-286		
Type 316	A182 Gr. F316	SA182 Type F316 & F316H	21.95
(annealed and	A276 Type 316		
all heat treat's)	A473 Type 316		
	A479 Type 316	SA479 Type 316 & 316H	
Alloy L-605	Haynes 25 CA-7	N/A	26.19
	L-605		
Alloy 718	B637-N07718	N/A	23.06
	Inconel 718		